

IMG\_1816



IMG\_1817



IMG\_1818



IMG\_1819



Serial No. CSM4712021 Build Date: week 47 of 2002  
5 of 5

Serial No. CSR3103260 Model No. GHW9150PW0 Whirlpool Build Date: Week 31 of 2004

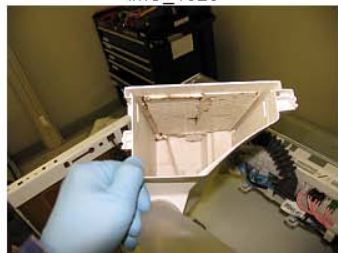
IMG\_1821



IMG\_1822



IMG\_1823



IMG\_1824



IMG\_1825



IMG\_1827



IMG\_1828



IMG\_1829



Serial No. CSR3103260 Build Date: week 31 of 2004  
1 of 5

IMG\_1830



IMG\_1831



IMG\_1832



IMG\_1833



IMG\_1834



IMG\_1835



IMG\_1836



IMG\_1837



Serial No. CSR3103260 Build Date: week 31 of 2004  
2 of 5



(Expert Report on Whirlpool Front Loading Washer Continued)

---

IMG\_1838



IMG\_1839



IMG\_1840



IMG\_1841



IMG\_1842



IMG\_1843



IMG\_1849



IMG\_1850



Serial No. CSR3103260 Build Date: week 31 of 2004  
3 of 5

IMG\_1851



IMG\_1852



IMG\_1853



IMG\_1854



IMG\_1855



IMG\_1856



IMG\_1857



IMG\_1858



Serial No. CSR3103260 Build Date: week 31 of 2004  
4 of 5

(Expert Report on Whirlpool Front Loading Washer Continued)

---

IMG\_1859



IMG\_1860



IMG\_1861



IMG\_1862



IMG\_1863



IMG\_1864



IMG\_1865



IMG\_1866



Serial No. CSR3103260 Build Date: week 31 of 2004  
5 of 5



## TEARDOWN IN CHARLOTTE, NORTH CAROLINA

Serial No. CSR0407232 Model No. GHW9250MT1 Whirlpool Build Date: Week 04 of 2004

IMG\_1867



IMG\_1868



IMG\_1869



IMG\_1870



IMG\_1871



IMG\_1872



IMG\_1873



IMG\_1874



Serial No. CSR0407232 Build Date: week 04 of 2004  
1 of 5

(Expert Report on Whirlpool Front Loading Washer Continued)

---

IMG\_1875



IMG\_1876



IMG\_1877



IMG\_1878



IMG\_1879



IMG\_1880



IMG\_1881



IMG\_1882



Serial No. CSR0407232 Build Date: week 04 of 2004  
2 of 5



(Expert Report on Whirlpool Front Loading Washer Continued)

---

IMG\_1883



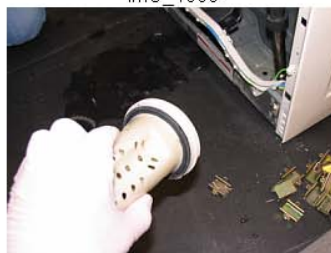
IMG\_1884



IMG\_1885



IMG\_1886



IMG\_1887



IMG\_1888



IMG\_1889

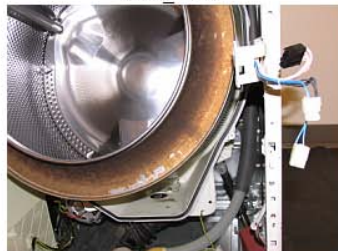


IMG\_1890



Serial No. CSR0407232 Build Date: week 04 of 2004  
3 of 5

IMG\_1891



IMG\_1892



IMG\_1893



IMG\_1894



IMG\_1895



IMG\_1896



IMG\_1897



IMG\_1898



Serial No. CSR0407232 Build Date: week 04 of 2004  
4 of 5

(Expert Report on Whirlpool Front Loading Washer Continued)

---

IMG\_1899



IMG\_1900



IMG\_1901



Serial No. CSR0407232 Build Date: week 04 of 2004  
5 of 5



Serial No. CSR3701615 Model No. GHW9150PW0 Whirlpool Build Date: Week 37 of 2004

IMG\_1902



IMG\_1903



IMG\_1904



IMG\_1905



IMG\_1906



IMG\_1907



IMG\_1908



IMG\_1909



Serial No. CSR3701615 Build Date: week 37 of 2004  
1 of 5

IMG\_1910



IMG\_1911



IMG\_1912



IMG\_1913



IMG\_1914



IMG\_1915



IMG\_1916



IMG\_1917



Serial No. CSR3701615 Build Date: week 37 of 2004  
2 of 5

IMG\_1918



IMG\_1919



IMG\_1920



IMG\_1921



IMG\_1922



IMG\_1923



IMG\_1924



IMG\_1925



Serial No. CSR3701615 Build Date: week 37 of 2004  
3 of 5



IMG\_1926



IMG\_1927



IMG\_1928



IMG\_1929



IMG\_1930



IMG\_1931



IMG\_1932



IMG\_1933



Serial No. CSR3701615 Build Date: week 37 of 2004  
4 of 5

IMG\_1934



IMG\_1935



IMG\_1936



IMG\_1937



IMG\_1938



IMG\_1939



Serial No. CSR3701615 Build Date: week 37 of 2004  
5 of 5

Serial No. CSS1208971 Model No. GHW9150PW0 Whirlpool Build Date: Week 12 of 2005

Copy of IMG\_1946



IMG\_2003



IMG\_2004



IMG\_2005



IMG\_2006



IMG\_2007



IMG\_2008



IMG\_2009



Serial No. CSS1208971 Build Date: week 12 of 2005  
1 of 6



IMG\_2010



IMG\_2011



IMG\_2012



IMG\_2013



IMG\_2014



IMG\_2015



IMG\_2016



IMG\_2017



Serial No. CSS1208971 Build Date: week 12 of 2005  
2 of 6

IMG\_2018



IMG\_2019



IMG\_2020



IMG\_2021



IMG\_2022



IMG\_2023



IMG\_2024

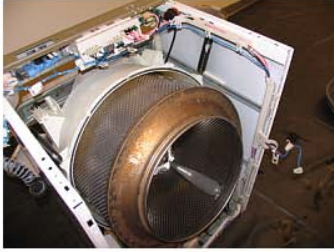


IMG\_2025



Serial No. CSS1208971 Build Date: week 12 of 2005  
3 of 6

IMG\_2026



IMG\_2027



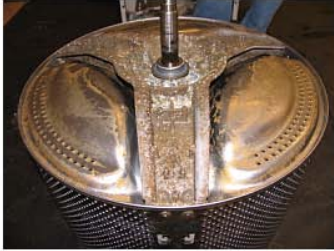
IMG\_2028



IMG\_2029



IMG\_2030



IMG\_2031



IMG\_2032



IMG\_2033



Serial No. CSS1208971 Build Date: week 12 of 2005  
4 of 6



IMG\_2034



IMG\_2035



IMG\_2036



IMG\_2037



IMG\_2038



IMG\_2039



IMG\_2040



IMG\_2041



Serial No. CSS1208971 Build Date: week 12 of 2005  
5 of 6

(Expert Report on Whirlpool Front Loading Washer Continued)

---

IMG\_2042



IMG\_2043



IMG\_2044



IMG\_2045



Serial No. CSS1208971 Build Date: week 12 of 2005  
6 of 6

Serial No. CSR1910188 Model No. GHW9100LW2 Whirlpool Build Date: Week 19 of 2004

Copy of IMG\_1940



IMG\_1940



IMG\_1941



IMG\_1942



IMG\_1943



IMG\_1944



IMG\_1945



IMG\_1946



Serial No. CSR1910188 Build Date: week 19 of 2004  
1 of 8

IMG\_1947



IMG\_1948



IMG\_1949



IMG\_1950



IMG\_1951



IMG\_1952



IMG\_1953



IMG\_1954



Serial No. CSR1910188 Build Date: week 19 of 2004  
2 of 8



IMG\_1955



IMG\_1956



IMG\_1957



IMG\_1958



IMG\_1959



IMG\_1960



IMG\_1961



IMG\_1962



Serial No. CSR1910188 Build Date: week 19 of 2004  
3 of 8

IMG\_1963



IMG\_1964



IMG\_1965



IMG\_1966



IMG\_1967



IMG\_1968



IMG\_1969



IMG\_1970



Serial No. CSR1910188 Build Date: week 19 of 2004  
4 of 8

IMG\_1971



IMG\_1972



IMG\_1973



IMG\_1974



IMG\_1975



IMG\_1976



IMG\_1977



IMG\_1978



Serial No. CSR1910188 Build Date: week 19 of 2004  
5 of 8



IMG\_1979



IMG\_1980



IMG\_1981



IMG\_1982



IMG\_1983



IMG\_1984



IMG\_1985



IMG\_1986



Serial No. CSR1910188 Build Date: week 19 of 2004  
6 of 8



IMG\_1987



IMG\_1988



IMG\_1989



IMG\_1990



IMG\_1991



IMG\_1992



IMG\_1993



IMG\_1994



Serial No. CSR1910188 Build Date: week 19 of 2004  
7 of 8

IMG\_1995



IMG\_1996



IMG\_1997



IMG\_1998



IMG\_1999



IMG\_2000



IMG\_2001



IMG\_2002



Serial No. CSR1910188 Build Date: week 19 of 2004  
8 of 8

## APPENDIX E: ACCESS VS HORIZON

A new ACCESS (Serial No. HLW3929761) and a new HORIZON (Serial No. HLY1212870) were purchased and operated and then tore down. The two washers operate similarly and there is very little functional difference between the washers. The HORIZON is slightly smaller overall and the key components such as the cabinet, tub and basket are smaller as well as the spin motor. However, all of the parts are very similar as is shown in the pictures below. The HORIZON is tagged with a red tag.



DUET Vs Sport  
 DUET Serial No. HLW8300SW05 Build Date: week 39 of 2008  
 Sport Serial No. HLY1212870 Build Date: week 12 of 2009  
 1 of 3



(Expert Report on Whirlpool Front Loading Washer Continued)

---

IMG\_2067



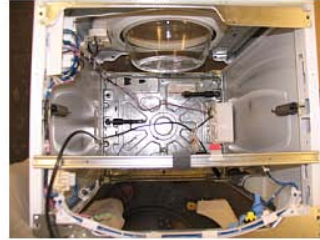
IMG\_2068



IMG\_2069



IMG\_2071



IMG\_2073



IMG\_2078



IMG\_2079



IMG\_2080



DUET Vs Sport

DUET Serial No. HLW8300SW05 Build Date: week 39 of 2008

Sport Serial No. HLY1212870 Build Date: week 12 of 2009

2 of 3



(Expert Report on Whirlpool Front Loading Washer Continued)

---



DUET Vs Sport

DUET Serial No. HLW8300SW05 Build Date: week 39 of 2008

Sport Serial No. HLY1212870 Build Date: week 12 of 2009

3 of 3

## APPENDIX F: PLAINTIFF VISIT

On August 24, 2009 I visited Tracy Snyder's house in Harrisburg, North Carolina. While there I removed the lower access panel and opened up the pump strainer area (see picture below). The strainer was contaminated and once opened an extremely foul odor was released. I cleaned the strainer and reassembled the pump and access panel. When running the unit to verify the proper assembly of the unit another foul odor was emitted during the drain indicating to that the drain hose was also contaminated.



## APPENDIX G: RESUME

(See separate attachment)

**R. Gary Wilson, Ph.D., P.E.**

**Home:**

**5834 Natoma Road  
Clover, SC 29710**

**Office:**

**University of North Carolina- Charlotte  
Mechanical Engineering and Engineering Science  
9201 University City Boulevard  
Charlotte, NC 28223**

**Home: (803) 831-2912**

**Email: [RGW48@YAHOO.COM](mailto:RGW48@YAHOO.COM)**

**Office: (704)687-8340**

**Email: [rwilso32@uncc.edu](mailto:rwilso32@uncc.edu)**

**EDUCATION**

**Case Western Reserve University, Cleveland, Ohio**

Ph.D. in Mechanical Engineering, 2004

Area of specialization: Thermal/Fluid Sciences. Dissertation: "A Numerical Analysis of the Influence of Korteweg Stresses on the Flow and Mixing of Miscible Fluids."

Research Advisor: J. Iwan D. Alexander.

**National Technological University, Fort Collins, Colorado**

Graduate Certificate of Completion in Aerospace Engineering, 1992

Completed twelve semester hours of NTU graduate courses with a focus in Aerospace engineering.

Academic Advisor: E. Sparrow, University of Minnesota

**University of Illinois, Urbana-Champaign, Illinois**

Master of Science in Mechanical Engineering, 1976

Area of specialization: Thermal Sciences, Thermal system simulation and optimization. Thesis: "The Simulation and Plan for Verification of the Performance of an Internal Source Heat Pump."

Research Advisor: W. F. Stoecker

**Tennessee Technological University, Cookeville, Tennessee.**

Bachelor of Science in Mechanical Engineering, 1975

Cooperative Education Program: One twelve month (four assignments) and one nine month (three assignments) Co-Op work periods with DuPont at the Savannah River Plant in Aiken, South Carolina.



### **AWARDS and HONORS**

Letter of commendation from the Dean of Undergraduate Studies for "...the good will, time and effort that you bring to your interaction with students", June 2003, Case Western Reserve University.

"Graduate Dean's Instructional Excellence Award" In Recognition of Providing Outstanding Instruction As a Graduate Teaching Assistant in Mechanical and Aerospace Engineering During the Academic Year 2000 – 2001, Case Western Reserve University.

Case Prime Fellowship, 2000 to 2004.

Letter of commendation and "Special Award" from the President of the Kenmore Appliance Group for "...outstanding work...with regard to the Kenmore ULTRA WASH dishwasher. Your proactive approach to managing the situation resulted in a substantial savings to the Kenmore Appliance Group," 1990.

Received an "Excellence Award" from the Kenmore Business Unit for the development of a New Generation Portable Dishwasher that secured 100% of Sears' portable dishwasher business, 1989.

"Award for the Best Presentation of a Technical Paper" presented at the 1988 International Appliance Technical Conference.

"Award of Excellence for a Technical Paper" presented at the 1988 International Appliance Technical Conference (primary author).

"Dana Chase Memorial Award for the Best Paper" presented to the 1987 International Appliance Technical Conference.

Sigma Xi Achievement award for "Excellence in Thermal System Simulation", 1980.

### **PROFESSIONAL LICENSING AND PATENTS**

"Variable Capacity Binary Refrigerant Refrigeration Apparatus," Inventors: Raymond Gary Wilson; Edwin H. Frohbieter, Patent No. 4,416,119.

Registered as Professional Engineer in Michigan (No. 27261)  
Registered as Professional Engineer in South Carolina (No. 27489)  
Licensed as a Model Law Engineer (No. 37207) by the NCEES

### **PROFESSIONAL SOCIETIES**

American Society of Mechanical Engineers  
American Society of Heating Refrigeration and Air Conditioning Engineers  
American Society for Engineering Education  
International Institute of Ammonia Refrigeration  
PI TAU SIGMA, Mechanical Engineering Honorary Society

## **PROFESSIONAL EXPERIENCE**

### **THE UNIVERSITY OF NORTH CAROLINA AT CHARLOTTE, Charlotte, NC, Fall 2005 through Spring 2008.**

Full Time Lecturer in the Mechanical Engineering and Engineering Science department. Taught Thermodynamics I, Thermal/Fluids Design, Thermal/Fluids Lab, Refrigeration and Air Conditioning, Stationary Power Plant Systems. [See teaching experience below.](#)

### **CASE WESTERN RESERVE UNIVERSITY, Cleveland, OH, Fall 1999 through Spring 2004.**

Full time graduate student.

### **WHIRLPOOL CORPOPRTATION, Benton Harbor, MI, 1976 to 1999**

Global leader in the design and manufacturing of home appliances with annual revenue of \$12 billion.

#### **Director, Laundry Technology, (1997 to 1999)**

Leading the design function consisting of over 80 Engineers, Designers, Drafters, Technicians, and Managers for two major projects that total over \$100 million in capital expenditure with an annual expense budget of \$12 million while implementing Six-Sigma / Robust design concepts.

- Assumed leadership and successfully restructured stalled clothes washer platform redesign. Incorporated innovative, breakthrough technology, improved design process to include robust design methodologies and brought project back on schedule.
- Secured Whirlpool's largest laundry customer representing 40% of annual revenue by accelerating the new platform project schedule three months through concurrent design and aggressive tooling process changes.
- Developed an interim design on an existing platform one year ahead of the long-range new platform project utilizing technology from new platform design.

#### **Director, Dishwasher Technology, (1994 to 1996)**

Directed North American Dishwasher Technology including two major projects totaling over \$36 million in capital, all model line development, cost and quality improvement and the evaluation laboratory. Managed a department of 70 technical staff members and a budget of over \$8 million annually.

- Designed new platform dishwasher that delivered enhanced consumer benefits at reduced cost, improving business unit profit from \$36 million to \$80 million in 24 months. New platform achieved Six-Sigma design and 60% part commonality between brand lines.
- Developed Whirlpool and Kenmore model lines with patented sound technology, common electronic architecture and best in industry performance and quality that resulted in receiving 7 of the top 10 Consumer Reports ratings and resulted in a four point market share increase.
- Implemented new CAD software that increased productivity 35% and was subsequently adopted as Whirlpool's global standard.

**PROFESSIONAL EXPERIENCE (Continued)**

**Manager, Cost & Quality, Dishwasher Technology, (1992 to 1993)**

Organized a new department to focus on cost and quality improvements for all brands. Led a staff of eight engineers and seven designer/drafters that implemented record levels of cost and quality improvements.

- Reduced cost \$7.5 million and improved quality by 25% over a two-year period by utilizing a well-coordinated design and manufacturing team.

**Manager, Kenmore Model Line, Dishwasher Technology, (1989 to 1991)**

Managed all Kenmore brand model line design upgrades, cost reductions, quality enhancements and production implementation. Kenmore line included 15 models with annual volume of 450,000 units.

- Upgraded line quality 42% by developing service ticket analysis, reliability growth plan and utilizing advanced engineering analysis to redesign circuit board connectors.
- Developed "America's Quietest" dishwasher through application of advanced sound measuring techniques.
- Developed and implemented into production the New Generation plastic tub portable dishwasher that won all Sears portable Dishwasher business.

**Project Team Leader, Research & Advanced Development (1985 to 1988)**

Managed "Skunk Works" department responsible for the development of high performance clothes washing system and an advanced insulation (vacuum panel insulation) for refrigeration application. The high performance washing system and advanced insulation were implemented into production.

- Team leader for the design, fabrication, and delivery of the Space Station and Space Shuttle appliances (refrigerator & dishwasher) ground test units. Wrote proposals (technical & cost) and won contracts for Space Station proof-of-concept galley Refrigerator/Freezer, Dishwasher, and Clothes washer/Dryer units, and flight Refrigerator/Freezer for the Space Shuttle.
- Wrote preliminary proposals (technical & cost) for phase C/D contracts for the Space Station galley appliances and Logistics Module including direct cooling Refrigerator/Freezers, thermoelectric Refrigerator/Freezers, and Dishwasher.

**Senior Product Engineer, Evansville Division, (1984)**

Product Engineering, Compressor Engineering Department

- In charge of the compressor engineering department that consisted of two engineers, six technicians, and a model shop with three union model makers.
- Maintained and operated compressor calorimeters and test program to evaluate purchased compressors.
- Conducted life tests and life tests evaluations using teardown analysis. Implemented statistical methods of evaluation for the calorimeter tests.

**PROFESSIONAL EXPERIENCE (Continued)**

**Research Engineer, Research and Engineering Center (1981 to 1983)**

Mechanical Systems Research Department, Thermal/Fluids Analysis Group

- Directed experimental program on binary refrigerant compressors, which allowed refrigerator capacity to be modulated to match thermal load. Resulted in a patent.
- Conducted an analytical optimization study on dual evaporator binary refrigerant refrigeration systems that assisted in the improved design of an experimental apparatus which demonstrated a 6 to 8% energy improvement.
- Developed an advanced room air conditioner simulation for Product Engineering, which resulted in a 20% design cycle time reduction.

**Project Engineer, Research and Engineering Center (1978 to 1980)**

Mechanical Systems Research Department, Thermal/Fluids Analysis Group

- Directed two technicians on an experimental program to evaluate two evaporator refrigerators that utilized non-azeotropic binary refrigerant mixtures.
- Developed a thermal analysis package for evaluating refrigeration systems, which resulted in reduced cycle time for the development of refrigeration system simulations and is still in use today.
- Developed a package of optimization programs to be utilized with thermal system simulations.

**Engineer, Research and Engineering Center (1976 to 1977)**

Mechanical Systems Research Department, Thermal/Fluids Analysis Group.

- Developed finned-tube-condenser simulation for general application to refrigeration products.
- Developed a heat pump simulation (heating and cooling modes) for use by Product Engineers. This simulation was key in allowing the company to enter the residential heat pump business and in the reduction of design cycle time.
- Developed a generalized computer program for the steady-state simulation of thermal systems.
- Lead in the evaluation and acquisition of CSMP (Continuous System Modeling Program), which was used to develop transient simulations of domestic ovens and commercial icemakers.



## **TEACHING EXPERIENCE**

**Lecturer**, The University of North Carolina at Charlotte

Courses: Thermodynamics I and Thermal/Fluids Design, Fall 2005.

- Taught a traditional Mechanical Engineering Thermodynamics I class.
- Redesigned the Thermal/Fluids Design class (a major project class) by dividing the students into competitive companies that worked on the same project. Each company was divided into departments. The departments within each company had to work together in order to execute the project.

Courses: Refrigeration and Air Conditioning, Thermal/Fluids Design, Thermal/Fluids Lab: Spring 2006.

- Designed and taught the Refrigeration and Air Conditioning class. Covered topics such as multi-pressure vapor compression systems, heat exchanger design for simultaneous heat and mass transfer, and Psychrometrics.
- Modified the Thermal/Fluids Design class to include additional lecture topics on thermal system components (piping circuits, pumps, fans, heat exchangers) and thermal system simulation.
- Took over and taught the last two labs in the Thermal/Fluids Lab class.
- Mentored one Senior Design I project.
- Began implementation of WEBCT for the Thermal/Fluids Design class.

Courses: Thermal/Fluids Design, Thermal/Fluids Lab: Fall 2006, Spring 2007, Fall 2007.

- Fully integration WEBCT/Blackboard into both courses. All course documents, reports and homework assignments submitted electronically and graded and returned electronically (PDFs). Introduced CAE software program MathCad into the courses and required all homework assignments and analysis for reports be executed in MathCad.
- Introduced two new labs (cross flow heat exchanger and refrigeration system) and three mini-labs in the thermal/fluids lab class. Video recorded three lab experiment introductions and began using the recordings Fall '07.
- Mentored one Senior Design II project and one Industry sponsored Senior Design I project (Stabilus) Fall '06. Spring '07 mentored Industry sponsored Sr. Design II project (Stabilus hired two of the students). Summer '07 placed two summer intern students with Electrolux dishwasher division in Kinston, NC and supervised a graduate student summer research project (National Gypsum). The graduate student was hired by Electrolux. Fall '07 summer intern students returned with an Electrolux sponsored Sr. Design I project that I mentored.

Courses: Thermal/Fluids Design, Thermal/Fluids Lab, Refrigeration and Air Conditioning: Spring 2008.

- Started up the lab class and the passed responsibility to another professor after the first lab. Will resume responsibility for the last lab.
- Mentoring one Sr. Design II project and three Sr. Design I projects. Placed three summer intern students with Electrolux refrigerator division in Anderson, SC.

**Graduate Teaching Assistant I, Case Western Reserve University**

Course: Fluid and Thermal Engineering II, Fall 2000, Instructor: Professor James T'ien

Conducted a weekly recitation class for approximately 25-30 third year mechanical engineering students. Reinforced lecture topics, worked example problems, answered questions, and lectured on special topics. Also, graded exams and homework assignments, suggested problems for the exams, reviewed homework problems during the lecture and maintained office hours for individual student assistance.

**Graduate Teaching Assistant II, Case Western Reserve University**

Course: Introduction to Thermodynamics, Fluid Dynamics, Heat and Mass Transfer, Spring 2001, Instructor: Professor Iwan Alexander (advisor)

Conducted a weekly recitation class for approximately 35-40 second year engineering students. Reinforced lecture topics, worked example problems, answered questions, and lectured on special topics. Also, graded exams and homework assignments, suggested problems for the exams and maintained office hours for individual student assistance. Provided leadership for the graduate assistant group (there were eight T/A's for this course) by organizing the grading of exams, calling meetings when required, and helping to maintain consistency in the grading of exams and homework.

**Graduate Teaching Assistant III, Case Western Reserve University**

Provided general teaching assistance for my advisor by providing support upon request, Fall 2001.

**Instructor for Engineer in Training and Professional Engineer examinations, St. Joseph/Benton Harbor, Michigan**

Instructor for Fluid Mechanics, Thermodynamics, and Heat Transfer reviews for the Engineer in Training and Professional Engineer examinations. Annual reviews sponsored by the Michigan Society of Professional Engineers, 1976-1998.

**TEACHING INTEREST**

The traditional Thermal Sciences: Fluid Dynamics, Thermodynamics, and Heat Transfer

Computational Fluid Dynamics

Refrigeration

Mechanical and thermal system design including six-sigma design concepts, robust design and the design process. Incremental design improvements involving total cost productivity (cost & quality improvements), as well as major design projects and project management.

**RESEARCH INTEREST**

Computational fluid dynamics, Korteweg Stresses and Dynamics at Miscible Fluid Interfaces. Incompressible flow of fully miscible fluids and stability at fluid interfaces.

Various Computational Fluid Dynamics methods and Cluster/Parallel Computing.

Thermal System Simulation and Optimization (particularly refrigeration systems) to aid in the design process and performance improvement.

The general design process and how design organizations interact with functions such as Marketing, Procurement, Manufacturing, and management. The cross functional design organization.

Design concepts such as the application of design-of-experiments to the design process, robust design, and the statistical tolerance design process.

## **RESEARCH EXPERIENCE**

**Doctoral Research:** Department of Mechanical and Aerospace Engineering, Case Western Reserve University, research adviser: Dr. Iwan Alexander, 2002 to present.

Topic: Computational Fluid Dynamics and Korteweg Stresses: Dynamics at Miscible Fluid Interfaces

Primitive variable, full Navier-Stokes Computational Fluid Dynamics computer code written to evaluate the mixing of two fully miscible fluids with constant density and variable viscosity flowing in a two-dimensional slot with and without Korteweg stress terms.

Numerical studies conducted to determine the effect of Korteweg stress on the interface between a more viscous fluid displacing a less viscous fluid at low Reynolds number, high Peclet number and high viscosity ratio.

**Industrial Research:** Whirlpool Corporation, Mechanical Systems Research Department, Benton Harbor, Michigan, 1976-1983.

Topic: Non-Azeotropic Binary Refrigerant Mixtures for efficiency improvement.

Computer simulation and experimental refrigeration systems were utilized to evaluate energy efficiency improvements in domestic refrigerators by taking advantage of the temperature glide that occurs when the refrigerant mixture changes phase. Through the use of dual evaporator systems energy improvements of 6 to 8% were demonstrated.

Topic: Non-Azeotropic Binary Refrigerant Mixtures and refrigeration capacity modulation.

A method to modulate the refrigeration capacity of a domestic refrigerator in order to match the thermal load using a variable mixture binary refrigerant working fluid was studied and resulted in patent "Variable Capacity Binary Refrigerant Refrigeration Apparatus," Inventors: Raymond Gary Wilson: Edwin H. Frohbieter, Patent No. 4,416,119 November 22, 1983.

Topic: Room Air Conditioner and residential size heat pump steady-state thermal system simulations.

Simulations of room air conditioner and heat pump systems were developed to assist design engineers and to support development projects.



**RESEARCH EXPERIENCE (Continued)**

**Masters Thesis Research:** Department of Mechanical Engineering, The University of Illinois at Urbana-Champaign, Illinois, research adviser: Dr. Will F. Stoecker, 1975-1976.

A steady-state simulation of an internal source heat pump that was operating in a Federal building in Raleigh, North Carolina was developed along with an experimental set-up, which was installed and made operational for data collection to verify the simulation. In a follow-up thesis, a study using the simulation identified a malfunction in the heat pump system which when corrected resulted in a major improvement in the efficiency of the system and confirmed the simulation.

R. Gary Wilson

Page 11 of 22

**TECHNICAL PAPERS**

"Validation Using the Driven Cavity Test Problem of a Navier-Stokes Equation Solver which Utilizes the Pressure Poisson Equation on a Non-Staggered Grid," paper accepted for Poster presentation during the Fourth International Conference on Computational Heat and Mass Transfer which will be held in Paris France May 17-20, 2005.

"A Thermoelectric Refrigerator/Freezer for the Space Station," R. Gary Wilson, W. Sargeant White, Nihat Cur, and David Mundy. Presented at the 39th Annual International Appliance Technical Conference and contained in the Proceedings, University of Wisconsin, Madison, Wisconsin, May 2-3, 1988. Winner of the "Award of Excellence for a Technical Paper."

"Space Station Appliances: Design Problems Encountered During the Development of Ground Test Units," IEEE Transactions on Industry Applications, March/April 1988, Vol. 24, No. 2, pg 317-321. Presented at the 38th Annual International Appliance Technical Conference and contained in the Proceedings, Ohio State University, May 12-14, 1987. Winner of the "Dana Chase Memorial Award for Best Paper" presented at the 1987 International Appliance Technical Conference and reprinted in Appliance, October 1987, vol 44, No. 10, pg 80-83.

"A Dishwasher for the Space Station," R. Gary Wilson and Jon Tromblee, SAE Paper No. 871411, Presented at the 17th Intersociety Conferences on Environmental Systems, Seattle, WA, July 13-15, 1987.

"Thermal System Design Using Computer Simulation," Presented at the 35th Annual International Appliance Technical Conference and contained in the Proceedings, Ohio State University, Columbus, Ohio, May 15-16, 1984.

"Computer Simulation," Technical paper and presentation delivered at the College Educators in Home Equipment meeting at Whirlpool Corporation, Benton Harbor, Michigan October 28-30, 1981.

**TECHNICAL PRESENTATIONS**

"Space Station Appliances," Presentation, St. Joseph-Benton Harbor Michigan Rotary Club, St. Joseph, Michigan, November 30, 1987.

"Space Station Appliances: Design Problems," Presentation, National Technical Conference of College Educators in Home Equipment, Morristown, New Jersey, October 13-14, 1987. Contained in the CEHE Proceedings.

"A Dishwasher for the Space Station," R. Gary Wilson and Jon Tromblee, SAE Paper No. 871411, Presented at the 17th Intersociety Conferences on Environmental Systems, Seattle, WA, July 13-15, 1987.

"Space Station Dishwasher and Refrigerator/Freezer Hardware Overview and Advanced Concepts," A technical presentation at the Space Station Food System Symposium sponsored by Lockheed Engineering and Management Services Company, Inc., Houston, TX, May 1, 1986.

"Modeling of Thermal Systems," text of a talk delivered at the National Design Engineering Show and ASME Conference, March 26-29, 1984 at the McCormick Place, Chicago, Illinois.

"Thermal System Design Using Computer Simulation," Presented at the 35th Annual International Appliance Technical Conference and contained in the Proceedings, Ohio State University, Columbus, Ohio, May 15-16, 1984.

"Thermal System Simulation and Optimization," Lecture presented at the Design Optimization Institute and Workshop, University of Arizona, Tucson, Arizona, May 14-17, 1984.

"Thermal System Simulation and Optimization," Lecture presented at the Design Optimization Institute, University of Arizona, Tucson, Arizona, April 11-15, 1983.

"Computer Simulation," Technical paper and presentation delivered at the College Educators in Home Equipment meeting at Whirlpool Corporation, Benton Harbor, Michigan October 28-30, 1981.

"Thermal System Simulation in the Appliance Industry," Technical Seminar presented to the Mechanical Engineering Graduate School at the University of Illinois in Urbana-Champaign, November 1978.

"In Focus," Whirlpool Corporation video magazine presented at each quarterly review, Six-minute interview on the Space Station Appliances, Volume 4, No. 1, February 1987.

"Space Station Appliances," Video News Release, 14 minutes of presentation and question/answers on the Space Station proof-of-Concept Appliances delivered to McDonnell Douglas Astronautics Company, April 1987.

**PROPOSALS WRITTEN**

"Advanced Thermoelectric Refrigerator/Freezer Proposal,' Technical and Cost Delta proposals for contract scope changes to existing contract with McDonnell Douglas Astronautics Company, Huntington Beach, CA, September 1987.

"Space Station Dishwasher Phase C/D Preliminary Proposal," Technical and Cost proposals for a subcontract with McDonnell Douglas Astronautics Company, Huntsville, AL, January 1987.

"Space Station Habitability Module Thermoelectric Refrigerator/Freezer and Logistics Module Refrigerator/Freezers Phase C/D Preliminary Proposals," Technical and Cost proposals for a subcontract with McDonnell Douglas Astronautics Company, Huntsville, AL, January 1987.

"Space Shuttle Thermoelectric Refrigerator/Freezer Project Proposal," Technical and Cost Proposals for a subcontract with McDonnell Douglas Astronautics Company, Huntington Beach, CA, November 1986. Subcontract No. 86716057 awarded to Whirlpool Corporation.

"Space Station Habitability Module Direct Cooling Refrigerator/Freezer and Logistics Module Refrigerator/Freezers Phase C/D Preliminary Proposals," R. Gary Wilson and W. Sargeant White, Technical and Cost preliminary proposals for a subcontract with Martin Marietta Denver Aerospace, Denver, CO, December 1986.

"Space Station Refrigerator, Freezer, and Dishwasher Design Project Proposal," Technical and Cost proposals for a subcontract with McDonnell Douglas Astronautics Company, Huntington Beach, CA as part of the NASA Space Station Advanced Food Hardware contract, November 1985. Subcontract No. 85716083 awarded to Whirlpool Corporation.

"Space Station Clothes Washer/Dryer Project Proposal," Technical and Cost proposals for a subcontract with McDonnell Douglas Astronautics Company, Huntington Beach, CA, December 1985. Subcontract No. 85716084 awarded to Whirlpool Corporation.



R. Gary Wilson

Page 14 of 22

**DESIGN REVIEWS and FINAL REPORTS**

"Preliminary Design Review Package and Presentation, Advanced Thermoelectric Refrigerator/Freezer," R. Gary Wilson, W. Sargeant White and Team, Subcontract No. 86716057 with McDonnell Douglas Astronautics Company Huntington Beach, CA, presented at NASA-JSC, Houston TX, October 1987.

"Final Report, Space Station Refrigerator/Freezers," R. Gary Wilson and Team, Subcontract No. 85716083 with McDonnell Douglas Astronautics Company Huntington Beach, CA, June 1987.

"Final Report, Space Station Dishwasher," R. Gary Wilson and Team, Subcontract No. 85716083 with McDonnell Douglas Astronautics Company Huntington Beach, CA, June 1987.

"Critical Design Review, Space Station Dishwasher and Refrigerator/Freezer," R. Gary Wilson and Team, Subcontract No. 85716083 with McDonnell Douglas Astronautics Company Huntington Beach, CA, September 1986.

**PROJECT REPORTS**

Ice Maker condenser simulation or a Generalized Finned Tube Condenser Simulation (30 pages + Appendix)

Review of an Oak Ridge National Laboratory Publication on a Heat Pump Simulation (8 pages + Appendix)

Five Thermodynamic Properties of Refrigerant II Curved Fitted (40 pages)

TAP - A Thermal Analysis Package (91 pages)

Binary Refrigerant Refrigerator System Comparisons Using R-12/ R-114 Mixtures (18 pages + Appendix)

Subroutines for the Calculation of the Thermodynamic and Thermophysical Properties of Refrigerants (21 pages + Appendix)

A Binary Refrigerant Refrigerator Simulation - Single Evaporator and Suction Line Heat Exchanger (21 pages + Appendix)

Binary Refrigerant Refrigerator System Experimental Program; The Conventional Configuration (29 pages)

Binary Refrigerant Compressors - A Preliminary Evaluation (13 pages)

Heat Pipe Furnace Optimization (10 pages)

Conditions Under Which Dehumidifiers and Air Conditioners Should be Utilized (5 pages + Appendix)

Restructured ACSIM, An "On Design" Simulation of Room Air Conditioners (72 pages)

Restructured ACSIM User Manual (26 pages + Appendices)

An Experimental Evaluation of Rotary Compressor Performance on Various Mixtures of R12 and R114 (7 + Appendix)

Simulation Study of An Evaporative Air Conditioner (17 + Appendices)

Evaluation of a U-Shaped Condenser Coil for Room Air Conditioners (14 pages + Appendices)

Thermodynamic Property Equations for Saturated R-12 Simplified for Use with Microcomputers and Programmable Calculators (10 pages + Appendices)

**PROJECT REPORTS (Continued)**

Binary Refrigerant Refrigeration System Experimental Program; The Dual Evaporator Configuration (25 pages + Appendix)

An Air Conditioner/Dehumidifier Simulation and Feasibility Study (16 pages + Appendix)

An Air Conditioner/Dehumidifier Simulation Study at Off-Design Conditions (13 pages)

Restructured ACSIM - An "Off-Design" Simulation of Room Air Conditioners (30 pages + Append.)

Development of Curve Fitting Equations for the Analog Flanging Function of the Solid Phase Refrigerator Liner (17 pages)

Binary Refrigerant Optimal Area Distribution Study - R-12/R-114 (13 pages + App. A & B)

R. Gary Wilson

Page 17 of 22

**GRADUATE COURSES TAKEN**

<b><u>Catalog Number</u></b>	<b><u>Course Title</u></b>	<b><u>Department</u></b>	<b><u>Institution</u></b>
TAM 441	Applied Analysis In Engineering I	Theoretical and Applied Mechanics	Univ. of Illinois at Urbana
TAM 442	Applied Analysis In Engineering II	Theoretical and Applied Mechanics	Univ. of Illinois at Urbana
ME 301	Thermodynamics	Mechanical Engineering	Univ. of Illinois at Urbana
ME 306	Industrial Heat Transfer	Mechanical Engineering	Univ. of Illinois at Urbana
ME 323	Design of Thermal Systems	Mechanical Engineering	Univ. of Illinois at Urbana
ME 305	Thermodynamics of High Velocity Flow	Mechanical Engineering	Univ. of Illinois at Urbana
ME 423	Thermal Systems	Mechanical Engineering	Univ. of Illinois at Urbana
TO 760-G	Project Management	Industrial Engineering	Univ. of Alaska at Fairbanks/NTU
AE 711-Y	Fluid Mechanics	Aerospace Engineering	Univ. of Washington /NTU
AE 710-Y	Principles of Dynamics	Aerospace Engineering	Univ. of Washington /NTU
AE 715-C	Intermediate Heat Transfer	Mechanical Engineering	Univ. of Minnesota /NTU
AE 716-C	Convection	Mechanical Engineering	Univ. of Minn./NTU
ME 530-C	Intermediate Heat Transfer	Mechanical Engineering	Univ. of Minn./NTU
ME 735-C	Conduction	Mechanical Engineering	Univ. of Minn./NTU
ME 736-C	Radiation	Mechanical Engineering	Univ. of Minn./NTU
TO 574-O	Industrial Experimentation	Industrial Engineering	Oklahoma State Univ. /NTU
EMAE 557	Convection Heat Transfer	Mechanical Engineering	Case Western Reserve Univ.



R. Gary Wilson

Page 18 of 22

**GRADUATE COURSES TAKEN (Continued)**

<b><u>Catalog Number</u></b>	<b><u>Course Title</u></b>	<b><u>Department</u></b>	<b><u>Institution</u></b>
Math 445	Introduction to Partial Differential Equations	Math	Case Western Reserve Univ.
EMAE 453	Advanced Fluid Dynamics I	Mechanical Engineering	Case Western Reserve Univ.
EMAE 460	Fluid Machinery	Mechanical Engineering	Case Western Reserve Univ.
EMAE 570	Computational Fluid Mechanics	Mechanical Engineering	Case Western Reserve Univ.
EMAE 454	Advanced Fluid Dynamics II	Mechanical Engineering	Case Western Reserve Univ.

R. Gary Wilson

Page 19 of 22

**SHORT COURSES TAKEN**

Black Belt – RPDP Management, A one week course, June 29, 1999.

Basic C<sub>pk</sub>, Whirlpool Internal Course, June 12, 1998.

Facilitation Techniques, Three day course presented by The Villard Group, May 14, 1997.

Coaching for Success, Two day course presented by the Villard Group, February 27-28, 1997.

Consulting Strategies and Skills, Three day course by the Villard Group, July, 1997.

Operational Excellence Management Workshop, Presented by Six Sigma Associates, Inc., Five day course, September 1996.

Whirlpool Leadership Academy, Developing Whirlpool Leaders, Five day course, June 1996.

Product Safety Tools Course, Whirlpool Product Safety Group, July 1995.

Understanding and Using C2C, The Product Development Process, Whirlpool internal course, March 1995.

Product Safety Orientation - #7930, Whirlpool internal course, August 1994.

Eighth Annual Engineering/Management Program, Krannert Graduate School of Management, Purdue University, West Lafayette, IN, April 26 – May 1, 1993.

Tools for Quality Improvement, Two day Whirlpool Internal Course, September 1992.

Taguchi Methods, Two day course taught by external consultant Dr. John Terninko, May 1992.

Marketing Management (E/M 151), Managerial Accounting and Financial Analysis (E/M 160 ), Understanding, Competitive Advantage (E/M 220 ), Decision and Network Analysis for Project Management (E/M 141), Engineering /Management Program, Purdue University, West Lafayette, IN, April 29 - May 4, 1991.

Benchmarking, Two day course, External consultant, November 1991.

Recruiter Training, Two day course, External consultant, September 1990

The Managerial Grid, Scientific Methods, Inc., Chicago, IL, Six (6) day seminar, 1990

Reliability in Engineering Design, Western Michigan University, Professor L. R. Lamberson, Three (3) day seminar, 1989.

**SHORT COURSES TAKEN (Continued)**

Plastic Part Design for Injection Molding, Paulson Training Program, One (1) day seminar, 1989.

Creative Planning, McNellis Co. Three (3) day seminar, 1988.

Reliability Engineering Principles University of Arizona via NTU, One (1) day seminar, 1988.

Statistics, Whirlpool internal seminar, Five (5) day seminar, 1983.

Experimental Design, Whirlpool internal seminar, Five (5) day seminar, 1983.

Data Communication and Microcomputer Interfacing., University of Illinois at Urbana-Champaign, Professor W. F. Stoecker, May 17 - May 21, 1982.

Operational Amplifiers, Six (6) week video course, 1982.

Microcomputer Control of Refrigeration and Air Conditioning Systems, University of Illinois at Urbana-Champaign, Professor W. F. Stoecker, May 18 - May 22, 1981.

Introduction to Optimal Design, University of Arizona. Tucson AZ, Professor K. Ragsdell, Five (5) day seminar, 1981.

Introduction to Microcomputers, IMTP, Six (6) week course, 1979.

Applied Numerical Methods, University of Michigan, Arbor, MI, Five (5) day seminar, Professor B. Carnahan, 1977

## **ENGINEERING SOFTWARE DEVELOPED**

### Thermoelectric Refrigeration System Simulation

Developed a simulation of the Space Shuttle refrigerator/freezer refrigeration system to aid in the design of the unit.

### Heat Pump Simulation

Developed a detailed first principles design model for both heating and cooling modes of operation. Worked with product engineers to verify the simulation and provided consultation on how to apply the program.

### Room Air Conditioner Simulation

Totally restructured an existing first principles simulation for solution by the Newton-Ralphson method and improved performance with optimization programs. Developed libraries of component data for coils, compressors, etc.

### Thermal Analysis Package

Developed a package of subroutines and function subprograms to support the development of refrigeration system simulations. The package consists of software to determine thermophysical and thermodynamic properties, heat transfer coefficients, pressure drop, and psychrometric properties. This package is used with the air conditioner, heat pump, refrigerator, and freezer simulations. By having this package of subroutines available, the development of new simulations has been considerably accelerated.

### Binary Refrigerant Refrigerator Simulation

Developed simulations of a single and dual evaporator binary refrigerant refrigerator for energy consumption evaluation. The simulation was used to predict trends and aid in two experimental programs.

A considerable number of support software packages (some of which are interactive) were developed for the binary refrigerant research program. These programs predict thermodynamic properties of mixed refrigerants, plotted T-X-P diagrams and P-h-X diagrams.



## **ENGINEERING SOFTWARE DEVELOPED (Continued)**

### Binary Refrigerant Refrigerator Optimization

Coupled the binary refrigerant refrigerator simulation to an optimization program to optimize the heat exchanger area distribution and refrigerant mixture ratio. Conducted a study using this software to evaluate energy performance with several refrigerant mixtures.

### Tube Calorimeter Simulation

A simulation of a tube calorimeter was developed to aid in the design and control of the calorimeter.

### Generalized Thermal System Simulation Package

Developed a standard software package for the simulation of thermal systems.

### Finned-Tube Condenser Simulation

Developed a generalized detailed condenser simulation for single component analysis and use with total system simulations.

### Freezer Simulation

I was instrumental in bringing a new engineer up to speed in the area of simulation and gave considerable guidance during the early stages of the transient freezer simulation development.

### Domestic Oven Simulation

Gave guidance during the early stages of the transient oven simulation development.

### Ice Maker Simulation

Gave guidance during the early stages of the transient ice maker simulation development.

### Refrigerator Simulation

Gave considerable guidance during the early stages of the development of the first new generation transient refrigerator simulation.

### Interactive Active Refrigerant Thermodynamic Properties Evaluation

Developed a program to interactively evaluate the superheat and saturated properties of ten different refrigerants (the subroutines in the Thermal Analysis Package were utilized).